
**Interbank Interest Rate Determination
in Singapore and its Linkages to
Deposit and Prime Rates**

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**INTERBANK INTEREST RATE DETERMINATION IN
SINGAPORE AND ITS LINKAGES TO DEPOSIT
AND PRIME RATES**

BY

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EXECUTIVE SUMMARY

1 This paper analyses the relative importance of global interest rates and domestic money market conditions in determining the local interbank rate, the extent to which currency factors create the differential between domestic and US interest rates, and the transmission mechanism from the domestic interbank rate to the prime lending and fixed deposit rates of banks.

2 The market-clearing domestic money market interest rate may be conceptualised as a weighted average of the interest rate level determined through uncovered interest arbitrage, and the level that would be sufficient to equate domestic money demand with existing money supply when the money market is closed to international capital flows. In order to analyse the relative importance of external and domestic factors in determining the domestic interbank rate, we model it as the outcome of a portfolio choice between money, domestic and foreign bonds, and domestic real assets. The results of our estimation show that changes in money supply or factors affecting the demand for money have no effect on the domestic interbank rate. Only changes in US interest rates or market expectations of future movements in the exchange rate have a significant impact on the domestic interbank rate.

3 If the domestic economy is completely integrated with the global economy, then arbitrage dictates that the uncovered interest parity, purchasing power parity and real interest parity conditions must hold *ex ante*. Due to data limitations, the standard procedure for testing these hypotheses is to determine if deviations from the parity conditions are systematically related to all known variables *ex post*. Our results for the sub-sample excluding the Asian currency crisis period show that *ex post* deviations from uncovered interest parity do not differ significantly from zero, indicating little systematic exchange rate risk premia or forecast errors. However, real interest parity and purchasing power parity are rejected, due to the presence of systematic inflation forecast errors.

4 We next evaluate how the prime lending and fixed deposit rates of banks respond to changes in the domestic interbank rate. In the Monti-Klein model, a monopolistic bank will change its deposit or prime rate only if the existing deposit or loan rate diverges from the profit-maximising rate as a result of a given change in the money market rate. The incentive to change these rates would be greater the larger the interest elasticity of loan demand or deposit supply. As the monopolistic power of banks increases, these elasticities become smaller, and deposit and loan rate rigidity increase. Moreover, the exercise of monopolistic power often results in asymmetric adjustments in deposit and loan rates, so that the deposit rate tends to rise more slowly (quickly), and the prime lending rate tends to rise more quickly (slowly), when the money market rate rises (falls).

5 Using a specification that allows only for symmetric responses, our results show that the response of the fixed deposit rate is larger than the response of the prime lending rate for a given change in the domestic interbank rate, with the mean lag of adjustment at 5.6 and 6 months respectively. The longer adjustment lag of the prime lending rate implies that the prime-deposit spread widens temporarily following a decline in the money market rate, and narrows temporarily as the interbank rate rises.

6 We also allow for differential speeds of adjustment in the prime and deposit rates for a given change in the domestic interbank rate. Using this formulation, our estimates indicate that neither the fixed deposit rate nor the prime rate displays any asymmetric adjustment pattern in response to a change in the domestic interbank rate. This may be attributed to the highly competitive nature of the banking industry in Singapore and the openness of the domestic economy. Borrowers are also free to deposit their funds and source their borrowing in different foreign currencies. The development of the private debt securities market as an alternative to bank loans will also serve to increase the competitiveness of prime and deposit rate pricing.

1 INTRODUCTION

1.1 This paper analyses various aspects of nominal interest rate behaviour for a small economy with an open and competitive financial market, namely:

- (i) the relative importance of the US interest rate and domestic money market conditions in determining the local interbank rate;
- (ii) the extent to which currency factors create the differential between domestic and US interest rates; and
- (iii) the manner in which changes in the interbank rate are transmitted to the prime lending and fixed deposit rates of banks.

II MONEY MARKET INTEREST RATE DETERMINATION IN A SMALL OPEN ECONOMY

2.1 Conceptually, the market-clearing domestic money market interest rate can be taken to be a weighted average of the interest rate level determined through uncovered interest parity arbitrage i^f , and the level that would be sufficient to equate domestic money demand with existing money supply under the condition where the money market is completely closed to international capital flows, i^* :

$$i_t = j i_t^{f*} + (1-j) i^* \quad (1)$$
$$0 \leq j \leq 1$$

where j is an index of the degree of openness in the money market to capital flows. Under the condition of perfect capital mobility, $j = 1$ and the actual interest rate level is determined by uncovered interest rate arbitrage, i.e. equal to the prevailing foreign interest rate adjusted for the expected rate of change in the spot exchange rate over the holding period. For an economy which is closed to international capital flows, $j = 0$ and the domestic interest rate is determined by the conditions that are necessary to eliminate any excess demand for money balances in the domestic money market.

2.2 Various models of interest rate determination for economies with different degrees of financial openness have been developed, using (1) as the underlying relationship [Edwards and Khan (1985), Haque and Montiel (1991)]. Another strand of literature has developed where time-varying estimates of j are used as measures of the progress in the liberalization of the capital account of the balance of payments [Reisen and Yeches (1993), Dooley and Mathieson (1993)].

2.3 In the Edwards and Khan (1985) model of interest rate determination, the solutions to interest rate determination in a closed and a

fully open economy are derived separately. The financial openness parameter, j , which links the international and domestic influences on the interest rate, is not derived within the model but is instead determined from empirical estimation.

2.4 An alternative model is proposed by Maloney (1997) and Chinn and Maloney (1998), in which the domestic interest rate is determined simultaneously as an outcome of a portfolio choice between non-interest bearing money, domestic currency bonds, foreign currency-denominated bonds and domestic real assets. The value of the openness coefficient depends on the degree of substitutability between the domestic currency bond and the foreign currency bond. When the degree of substitutability between these securities is high, any differential between the domestic interest rate and the foreign interest rate (adjusted for expectations of exchange rate changes) would induce uncovered arbitrage activities. The resultant capital flows, by eliminating the initial portfolio stock disequilibrium, determines the level of the domestic interest rate.

2.5 The reduced-form equation for the domestic interest rate which is derived from the model, in first difference form, is written as:

$$\Delta i_t = \mathbf{b}_1 \Delta DC_t + \mathbf{b}_2 CA_t + \mathbf{b}_3 \Delta Y_t + \mathbf{b}_4 \mathbf{p}_t^e + \mathbf{b}_5 \Delta W_t + \mathbf{b}_6 \Delta i_t^f \quad (2)$$

where DC is the central bank net domestic credit (domestic component of monetary base), CA is the current account, Y is the real income, \mathbf{p}^e is the expected rate of domestic inflation, W is the aggregate wealth of domestic portfolio holders, and i^f is the foreign interest rate adjusted for the expected change in the exchange rate. DC and CA influence the domestic interest rate through the supply of money. For instance, changes in the central bank net domestic credit alter the size of the monetary base, and through the money multiplier, the broad money supply. For a given demand for money, a change in the interest rate level is required to clear the money market. A shift in the current account position in a fixed or managed exchange rate

regime would affect the monetary base as the monetary authority undertakes unsterilized exchange market intervention aimed at maintaining the exchange rate peg. Changes in Y , W , i^f , and p^e affect the domestic interest rate through the demand for monetary assets as wealth holders rebalance their portfolio in response to shifts in these variables.

2.6 There is a direct relationship between the parameter of capital account openness, f , and the coefficients of the reduced form equation. In a situation where the capital account is completely closed, $f = 0$. Any movement in the foreign interest rate, adjusted for exchange rate expectation, would not lead to any portfolio substitution between domestic and foreign currency denominated assets. Hence $b_6 = 0$. The domestic interest rate would be determined by factors that influence domestic money supply and the demand for local assets. As the capital account opens up, the value of f rises. In the limit, as capital mobility becomes perfect, the coefficients b_1 to b_5 converge to zero and b_6 to unity. Any changes in domestic money supply or money demand which initially leads to incipient changes in the domestic interest rate will bring about offsetting capital movement that pushes back the interest rate to the level that is compatible with the existing level of international interest rates adjusted for exchange rate expectation.

2.7 We estimated equation (2) using quarterly data from 1988Q1 to 1998Q1. The Singapore money market interest rate is represented by the 3-month domestic interbank rate, income is measured by real GDP while the inflation rate is measured as the change in the logarithm of CPI. The change in the market value of domestic wealth is proxied by the change in the property price index. The foreign interest rate is represented by the 3-month US Dollar SIBOR interest rate. We assume the market forms rational forecasts of any change in the Singapore Dollar-US Dollar exchange rate

and we use the McCallum (1976) instrumental variable procedure to obtain a consistent estimate of the coefficient b_6 ¹. The estimated equation is:

$$\begin{aligned} \Delta i_t = & 0.103 + 3.68E-05 \Delta DC_t + 9.37E-07 CA_t + 3.52E-05 \Delta Y_t \\ & (0.078) \quad (3.39E-05) \quad (1.44E-05) \quad (6.49E-05) \\ & + 0.023 p_t^e - 0.004 \Delta W_t + 0.538 \Delta i_t^f \\ & (0.72) \quad (0.002) \quad (0.256) \end{aligned}$$

$$R^2 = 0.249 \quad DW = 1.646 \quad SE = 0.179$$

The figures in parentheses are Newey-West standard errors.

2.8 None of the coefficients, except that of the US Dollar SIBOR interest rate adjusted for the expected change in the exchange rate, are statistically significant at the 5% level. The estimates therefore indicate that under the current regime of managed exchange rates, any changes in the domestic money supply or factors affecting the demand for money would have no effect on the domestic interbank rate. Only changes in US interest rates or in foreign exchange market expectations of future movements in the Singapore-US Dollar exchange rate have a significant impact on the domestic money market interest rate.

¹ The instruments are lagged changes in the monetary authority's net domestic assets, real GDP growth, inflation, changes in the domestic interbank rate, as well as lagged changes in the exchange rate.

III FOREIGN INTEREST RATE LINKAGE AND INTERNATIONAL PARITY CONDITIONS

3.1 In this section we present a closer examination of the uncovered interest parity (UIP) condition that links the domestic interest rate to the foreign interest rate within the broader framework of the integration of the domestic financial and goods markets with the rest of the world. UIP is one of the three international parity conditions which represent equilibrium arbitrage conditions that will hold simultaneously if the financial market together with the goods market of an economy are completely integrated with the international economy. The other related parity conditions are the *ex ante* purchasing power parity (PPP) and the *ex ante* real interest parity (RIP).

3.2 The simultaneous determination of UIP, PPP and RIP can be seen as follows. The nominal uncovered interest parity is given by

$$i_{t+k} - i_{t+k}^f = S_{t+k}^e - S_t \quad (3)$$

where i_{t+k} is the nominal interest rate of the domestic currency asset purchased at time t and maturing at time $t+k$, i_{t+k}^f is the corresponding foreign interest rate with identical default risk, S_t is the logarithm of the spot exchange rate quoted at time t and S_{t+k}^e is the logarithm of the expectation of the spot rate formed at t for time $t+k$. Condition (3) holds only if investors are risk neutral and regard the domestic and foreign currency securities as perfect substitutes.

3.3 The *ex ante* PPP is given by

$$p_{t+k}^e - p_{t+k}^{ef} = S_{t+k}^e - S_t \quad (4)$$

where p_{t+k}^e and p_{t+k}^{ef} are the expected domestic and foreign inflation rates from period t to $t+k$ respectively. The *ex ante* PPP states that the expected

differential in the domestic and foreign inflation rates equals the anticipated rate of depreciation of the spot exchange rate. According to Roll (1979) and Alder and Lehmann (1983), in an efficient market, the expected return from speculating in storable commodities in different markets would be zero. This implies that expected changes in the real exchange rate would be equal to zero. The conventional PPP, on the other hand, requires that the actual change in the real exchange rate be equal to zero. The *ex ante* PPP, therefore, like UIP, is the outcome of efficient speculation where, instead of arbitraging in interest-bearing securities, the speculator invests in commodities.

3.4 Subtracting (4) from (3) yields the *ex ante* real interest rate parity condition:

$$\begin{aligned} 0 &= i_{t+k} - p_{t+k}^e - (i_{t+k}^f - p_{t+k}^{ef}) \\ &= R_{t+k}^e - R_{t+k}^{ef} \end{aligned} \tag{5}$$

where R_{t+k}^e and R_{t+k}^{ef} are the *ex ante* real interest rates on k -period domestic and foreign securities respectively. The *ex ante* real interest rates will equalise only if UIP and *ex ante* PPP hold simultaneously.

3.5 Although the three parity conditions are *ex ante* concepts involving exchange rate expectations and the expected rates of inflation, the standard test to evaluate whether each of these conditions holds has to resort to using observable *ex post* deviations from the parity conditions. The *ex post* deviation from UIP consists of the exchange rate risk premium r_{t+k} , and the exchange rate forecast error, $e_{t+k} = S_{t+k}^e - S_{t+k}$:

$$i_{t+k} - i_{t+k}^f - \Delta S_{t+k} = r_{t+k} + e_{t+k} \tag{6}$$

3.6 Similarly, the deviation from *ex ante* PPP is attributed to both the exchange rate forecast error and the inflation differential forecast error, \mathbf{m}_{t+k} :

$$p_{t+k} - p_{t+k}^f - \Delta S_{t+k} = \mathbf{m}_{t+k} + \mathbf{e}_{t+k} \quad (7)$$

3.7 Given (6) and (7), the *ex post* real interest rate differential is attributed to the presence of a risk premium and errors in forecasting inflation:

$$R_{t+k} - R_{t+k}^f = \mathbf{r}_{t+k} + \mathbf{m}_{t+k} \quad (8)$$

3.8 The standard procedure for testing the hypothesis that the parity conditions hold is to determine whether the deviations from the parity conditions are systematically related to variables that are in the information set. The test is essentially a joint test of the rationality of forecasts and the parity condition. If the parity condition holds and the forecast is rational, then the *ex post* deviation from the parity condition should not be systematically correlated with the variables in the information set.

3.9 Marston (1997) has pointed out that the power of the test can be enhanced if the three parity conditions are tested jointly in order to exploit the fact that common factors are responsible for the deviations from more than one of the parity conditions. For example, exchange rate risk premia are responsible for causing *ex post* departures from UIP and RIP, exchange rate forecast errors account for deviations from UIP and PPP, and inflation forecast errors explain the deviations from PPP and RIP.

3.10 Consider a system of three equations, with each equation relating the *ex post* deviations from a given parity condition to a common set of variables, Z_t , in an information set:

$$i_{t+k} - i_{t+k}^f - \Delta S_{t+k} = \mathbf{f}_0 + \mathbf{f}_1 Z_t + u_{t+k} \quad (9a)$$

$$p_{t+k} - p_{t+k}^f - \Delta S_{t+K} = I_0 + I_1 Z_t + v_{t+k} \quad (9b)$$

$$R_{t+k} - R_{t+k}^f = g_0 + g_1 Z_t + w_{t+k} \quad (9c)$$

3.11 The conventional single-equation test of UIP would involve estimation of equation (9a) and testing the null hypothesis that $f_I = 0$ [Giovannini and Jorion (1987), Cumby (1988), Bekaert and Hodrick (1992)]. The rejection of the null hypothesis would imply that the deviations from UIP can be due to the presence of risk premia and/or the presence of systematic forecast errors. In the single equation test, however, it is not possible to pinpoint the exact source of the departure from the UIP.

3.12 However, if additional information is available from equation (9c), a more definitive inference can be made. A rejection of the null hypothesis that $g_1 = 0$ and $f_I = 0$ would imply that risk premium, r_{t+k} , is responsible for the deviation in UIP and RIP. This is because the exchange risk premium is the only variable that is common to both equations (6) and (8).

3.13 Similarly, a rejection of the null hypotheses that $f_I = 0$ and $I_1 = 0$ would imply that the systematic exchange rate forecast error, ε_{t+k} , is responsible for the deviations from UIP and *ex ante* PPP.

3.14 The presence of the r_{t+k} term in both equations (6) and (8) can be tested by the cross-equation restriction $f_I = g_1$. This restriction, however, is equivalent to the restriction $I_1 = 0$ in equation (9b). The presence of ε_{t+k} in both equations (6) and (7) is tested by the cross-equation restriction $f_I = I_1$, which implies an equivalent restriction $g_1 = 0$ in equation (9c).

3.15 Figure 1 plots the monthly *ex post* deviations from UIP, PPP, and RIP for the sample period 1990Q1 to 1999Q2. The Singapore interest

rate is the 3-month domestic interbank rate while the foreign interest rate is the 3-month US Dollar SIBOR rate. The inflation rates for Singapore and US are measured as the percentage change in the consumer price index. Table 1 presents the unconditional means and variances of the *ex post* departures from the three parity conditions. As can be expected, the deviations from both UIP and PPP are much more volatile than the deviations from RIP as the former is driven by exchange rate forecast errors.

3.16 In Table 2 we report the test of the three parity conditions based on estimates of equations (9a), (9b), and (9c). The variables that we include in the information set Z_t are one month lagged changes in the Singapore Dollar SIBOR rate and the US Dollar SIBOR rate, and two month lagged Singapore and US inflation rates. All these variables are known when projections are made at each period t . The table shows the χ^2 statistics for the tests of the null hypothesis for each equation: $f_t = 0$ in the UIP equation, $I_t = 0$ in the PPP equation and $\gamma_1 = 0$ in the RIP equation. The test statistics reject the null hypothesis that each of the parity conditions hold. The rejection of $I_t = 0$ implies that the presence of a time-varying exchange rate risk premium is partly responsible for the deviation from UIP. The rejection of $g_t = 0$ indicates that systematic exchange rate forecast errors also account for the rejection of the UIP hypothesis.

3.17 Given that the deviations from the three parity conditions appear to be unusually large during the period following the outbreak of the Asia currency crisis (Figure 1), we estimated equations (9a) to (9c) and performed the orthogonality tests on a sub-sample that covers only the period 1990Q1 to 1997Q2, before the crisis. When the observations from the currency crisis period are excluded, the sample mean of the *ex post* deviations from UIP is -0.38 percent (as opposed to the mean of -1.17 percent when the entire sample is considered) and it is statistically not significant from zero (Table 1). The average deviations from PPP and RIP computed over the restricted sample are larger than the average deviations over the larger sample.

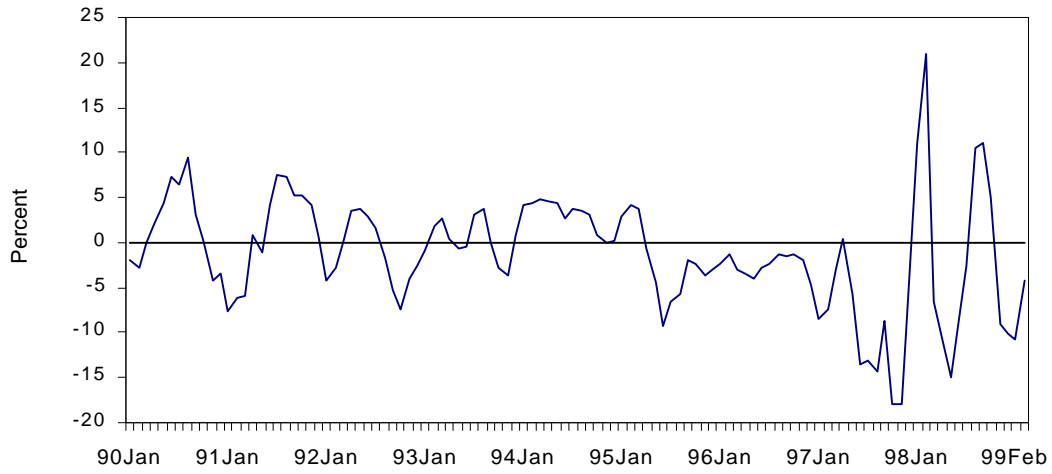
3.18 The chi-square tests of the three parity conditions based on the restricted sample are reported in Table 2. The test statistic indicates the restriction $f_t = 0$ underlying the UIP cannot now be rejected. The finding indicates that once the period of extreme market turbulence is excluded, there is little systematic exchange rate forecast error or exchange rate risk premium that causes persistent deviations from UIP.

3.19 The chi-square statistics reaffirmed the rejection of the restriction $I_t = 0$ in equation (9b) and $g_t = 0$ in equation (9c). The test results therefore confirm the rejection of RIP and this can be attributed to the presence of systematic inflation forecast errors.

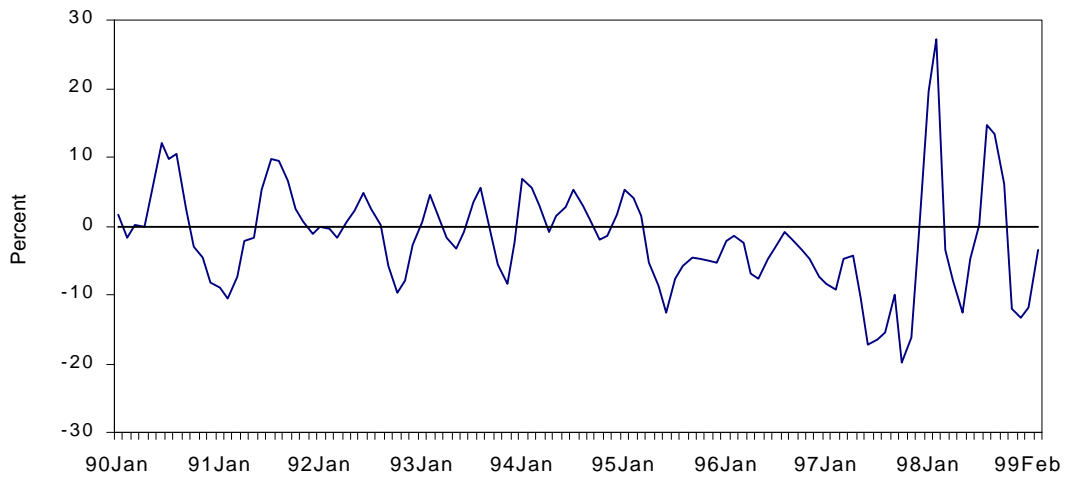
3.20 We now focus on the role of the exchange rate risk premium and the errors in forecasting the Singapore-US Dollar spot exchange rate in accounting for the failure of UIP to hold during the recent Asian financial crisis. As Figure 1 shows, the deviations from UIP were particularly large during the period of extreme market turbulence. For this purpose, we employ a different methodology which relies on survey data on exchange rate expectations to determine whether it is the presence of systematic forecast errors or the presence of a risk premium which led to the rejection of the UIP. We use the Economist Intelligence Unit (EIU) Currency Consensus Forecast to calculate the rate of change in the Singapore-US Dollar exchange rate expected by the market.

Figure 1

***Ex post* Deviations from UIP**



***Ex post* Deviations from PPP**



***Ex post* Deviations from RIP**

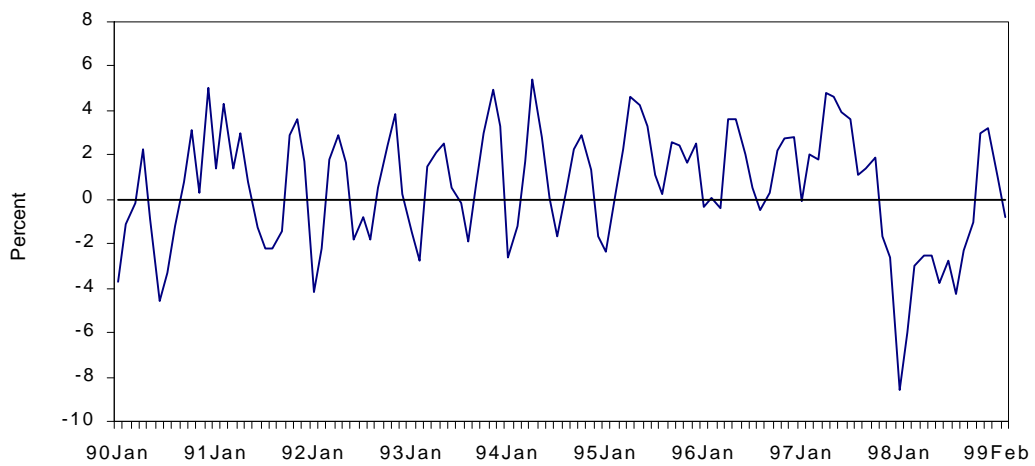


Table 1
Unconditional Means and Standard Deviation
of Deviations from UIP, PPP and RIP

	Deviation From UIP	Deviation From PPP	Deviation From RIP
1990Q1 – 1999Q2			
Mean	-1.1754 (0.0429)	-0.5963 (0.2915)	-0.5648 (0.0269)
Standard Deviation	6.0192	5.9006	2.6386
1990Q1 – 1997Q2			
Mean	-0.3800 (0.1682)	-0.6066 (0.000)	-0.9866 (0.000)
Standard Deviation	4.2313	4.0202	2.31639

Note: Figures in parentheses are p-values for the null hypothesis that the mean is zero.

Table 2
Testing for Systematic Deviations from UIP, PPP and RIP

	$f_l = 0$	$I_l = 0$ ($f_l = g_l$)	$g_l = 0$ ($f_l = I_l$)
1990Q1 – 1999Q2	21.822 (0.0002)	11.434 (0.022)	15.592 (0.004)
1990Q1 – 1997Q2	6.999 (0.1359)	14.251 (0.006)	21.121 (0.0003)

Note: The figures in the first row are $\chi^2(4)$ tests of coefficient restrictions. Figures in parentheses are p-values.

3.21 Consider the regression that is frequently used for testing UIP:

$$\Delta S_{t+k} = \mathbf{a}_0 + \mathbf{a}_1(i_{t+k} - i_{t+k}^f) + \mathbf{e}_{t+k} \quad (10)$$

where the rational expectation substitution $\Delta S_{t+k} = \Delta S_{t+k}^e + \mathbf{e}_{t+k}$ has been used. The test of the joint hypotheses of rational expectation and UIP would require that $\mathbf{a}_0 = 0$ and $\mathbf{a}_1 = 1$ and \mathbf{e}_{t+k} to be orthogonal to the information set. The probability limit of α_1 is:

$$\text{plim}(\mathbf{a}_1) = \frac{\text{cov}[\mathbf{e}_{t+k}, (i_{t+k} - i_{t+k}^f)] + \text{cov}[\Delta S_{t+k}^e, \mathbf{q}_t]}{\text{var}[i_{t+k} - i_{t+k}^f]} \quad (11)$$

where $\mathbf{q}_{t+k} = (i_{t+k} - i_{t+k}^f) - \Delta S_{t+k}^e$ is the risk premium. Following Frankel and Froot (1989), \mathbf{b}_0 can be expressed as:

$$\alpha_1 = 1 - \alpha_2 - \alpha_3 \quad (12)$$

where

$$\mathbf{a}_2 = \frac{\text{cov}[\mathbf{e}_{t+k}, (i_{t+k} - i_{t+k}^f)]}{\text{var}(i_{t+k} - i_{t+k}^f)} \quad (13)$$

and

$$\mathbf{a}_3 = \frac{\text{var}(\mathbf{q}_{t+k}) + \text{cov}(\Delta S_{t+k}^e, \mathbf{q}_{t+k})}{\text{var}[i_{t+k} - i_{t+k}^f]} \quad (14)$$

The use of survey data on exchange rate expectations allows us to determine whether deviations of \mathbf{a}_1 from unity are due to the presence of a risk premium, or persistent forecast errors, or both.

3.22 A test of the rationality of forecasts is performed by testing whether $\mathbf{d}_1 = \mathbf{d}_2 = 0$ in the following regression:

$$S_{t+k} - S_{t+k}^e = \mathbf{d}_1 + \mathbf{d}_2(i_{t+k} - i_{t+k}^f) + \mathbf{e}_{t+k} \quad (15)$$

3.23 The contribution of the exchange rate risk premium to the bias in a_1 can be evaluated by estimating the following equation and testing $a_2 = 0$ and $b_2 = 1$ in the following specification:

$$S_{t+k}^e - S_t = \mathbf{x}_1 + \mathbf{x}_2(i_{t+k} - i_{t+k}^f) + q_{t+k} \quad (16)$$

If agents are risk neutral and do not require a compensating risk premium, then x_2 can be expected to be equal to 1.

3.24 Estimates of equations (10), (15) and (16) using the Newey-West procedure are presented in Table 3. The coefficient of a_1 is negative, as is commonly found in the test of UIP. The Wald test rejects the null hypothesis of rational expectations and UIP at the 5% level. The coefficient restrictions implied by market rationality as well as those implied by risk neutrality are also rejected at the 5% level. Hence, our evaluation of the UIP using survey data indicates that the rejection of UIP is due to the fact that the participants in the foreign exchange market do not appear to be 'rational', and they also require a compensating risk premium to hold assets that are perceived to be subject to exchange rate risk.

Table 3
Tests of UIP, Risk Premium and
Rational Expectations Using Survey Data

	UIP	Rational Expectation	Risk Premium
α_0	0.354 (0.620)		
α_1	-2.637 (0.966)		
δ_1		0.746 (0.652)	
δ_2		-2.254 (1.101)	
ξ_1			-0.476 (0.403)
ξ_2			-1.927 (0.643)
R_2	0.354	0.151	0.173
χ^2	27.42	17.62	15.91

Note: Figures in parentheses are standard errors. χ^2 refers to the Wald test of coefficient restrictions implied by the null hypothesis.

IV LINKAGE BETWEEN THE MONEY MARKET AND THE PRIME AND DEPOSIT INTEREST RATES

4.1 In this section we evaluate how the prime lending rate and the fixed deposit rate of banks in Singapore respond to changes in the money market rate.

4.2 In the well-known Monti (1972) - Klein (1971) model of a banking firm, a monopolistic bank faces a downward-sloping demand for loans and an upward-sloping supply of deposits. The spread between the loan rate and the deposit rate depends on the size of the interest elasticity of demand for loans and the interest elasticity of supply for deposits. A bank will change its deposit or prime rate only if the existing deposit or loan rate diverges from the profit-maximising rate as a result of a given change in the money market rate. The amount and speed with which the deposit or loan rate will change will depend on the change in the optimal rate relative to the size of the adjustment cost. Flannery (1982) has shown that banks face significant adjustment costs in the retail deposit market as they seek to attract and maintain "core deposits". The recent literature on relationship lending by banks focuses on the high cost of investment incurred by lenders to counteract international asymmetries presented by borrowers and the effort to establish long-term relationships as a way of overcoming the problem [Peterson and Rajan (1994), Berger and Udell (1995)]. Developing a reputation for non-opportunistic behaviour on the part of the banks through the maintenance of a stable lending rate is one way of showing commitment to a long-term relationship.

4.3 Hannan and Berger (1991) and Cottarelli and Kourelis (1994) have shown that the incentive for a monopolistic bank to adjust either its deposit or loan rate in response to a given change in the money market rate would be when:

$$0.25b(Di)^2 > C \quad (17)$$

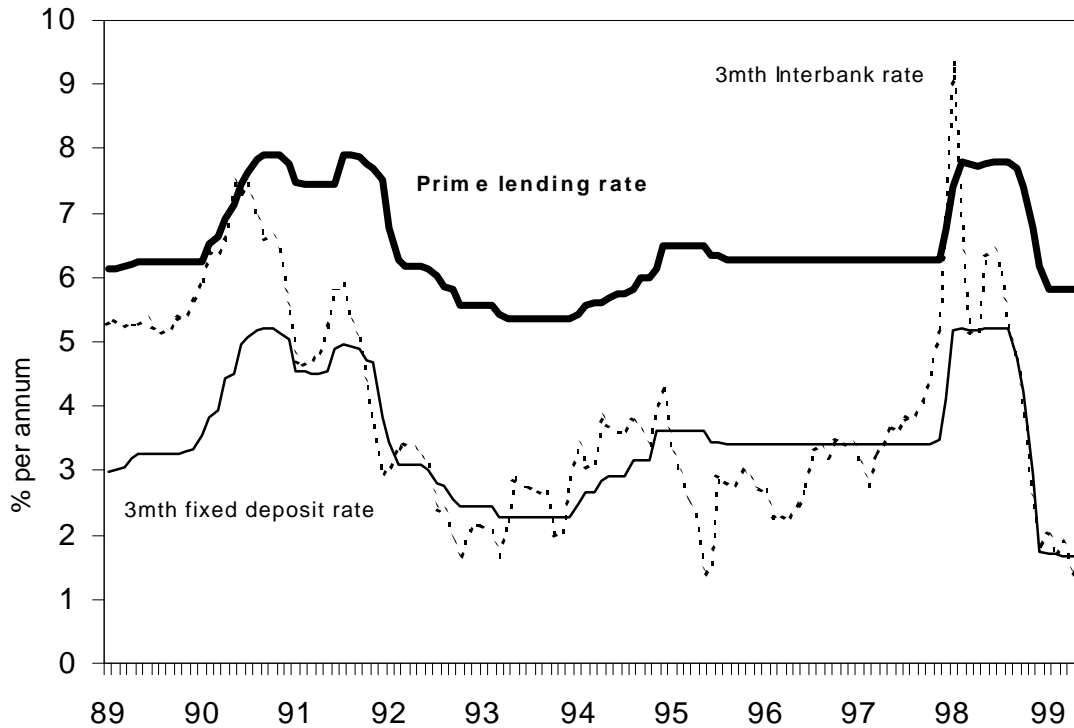
where b is the elasticity of demand for loans with respect to the lending rate or the elasticity of deposit supply with respect to the deposit rate, i is the money market rate, and C is the cost of either deposit or loan rate changes.

4.4 For a given adjustment cost, the incentive to change either the deposit or loan rate in response to a given shift in the money market rate would be greater the larger the elasticity of loan demand or the elasticity of deposit supply. The greater the monopolistic power that is wielded by the banking institutions and the more intense the conjectural interdependence among them, the smaller would be the value of b and the greater would be the rigidity of the deposit and loan rates. The exercise of monopoly power to extract maximum surplus from the customers and the need to maintain the cohesiveness of the banking cartel (formal or informal) would often result in the following asymmetric adjustments in the deposit and loan rates. When the money market interest rate rises, the deposit rate tends to rise more slowly. On the other hand, when the money market rate falls, the deposit rate is adjusted downward much more quickly. Such asymmetric deposit rate adjustments have been widely documented in the US by Newmark and Sharp (1992), Hannan and Berger (1991), and Sharp (1997). In the loan market, it has been found that the prime lending rate tends to be adjusted upward at a relatively faster rate during a period of tightness in the money market. When money market conditions ease and the interest rate falls, the prime rate tends to lag behind [Arak ef al (1983), Mester and Saunders (1990)].

4.5 Figure 2 shows the monthly plots of the three-month fixed deposit rate, the prime lending rate, and the three-month interbank rate. Both the prime as well as the fixed deposit rate responded with some lag to a given change in the interbank rate. The relative stickiness of the prime and deposit rates implies that during the period of declining interbank rates from 1990Q1 to 1993Q3, the spreads between these two rates and the interbank rate widened. When the interbank rate started to rise during 1993Q3 to the end of 1994 and from mid-1996 to the end of 1998, the spreads narrowed. The sharp increase in the interbank rate during the Asian

crisis from mid-1997 to early 1998 resulted in a precipitous fall in the spreads.

Figure 2
Interbank Interest Rate, Fixed Deposit Rate and Prime Lending Rate



4.6 We investigate the dynamic adjustment of the fixed deposit rate and the prime rate to a given change in the interbank interest rate within an error-correction model (ECM) framework. In the ECM model, we postulate a pair of equilibrium relationships between the interbank rate and the deposit and prime interest rates.

4.7 The ECMs for the fixed deposit and the prime rate are specified as:

$$\Delta i_t^D = a_0 + a_1 \Delta i_t + \mathbf{1} m_{t-1} \quad (18)$$

$$\Delta i_t^P = b_0 + b_1 \Delta i_t + \mathbf{d} e_{t-1} \quad (19)$$

where i^D is the fixed deposit rate, i^P is the prime rate, i is the interbank rate, and m_{t-1} and e_{t-1} are the error-correction terms estimated from the fixed deposit-interbank rate and prime-interbank rate cointegrating regressions respectively.

4.8 In order to allow for possible asymmetry in the adjustments of the deposit and prime rates to an increase and a decrease in the interbank rate we specify:

$$\Delta i_t^D = a_0 + a_1 \Delta i_t + l_1 m_{t-1}^+ + l_2 m_{t-1}^- \quad (20)$$

$$\Delta i_t^P = b_0 + b_1 \Delta i_t + d_1 e_{t-1}^+ + d_2 e_{t-1}^- \quad (21)$$

4.9 From the fixed deposit-interbank rate cointegrating regression we construct:

$$\begin{aligned} m_t^+ &= m_t & \text{if} & & m_t > 0 \\ m_t^+ &= 0 & \text{if} & & m_t \leq 0 \end{aligned}$$

and

$$\begin{aligned} m_t^- &= m_t & \text{if} & & m_t < 0 \\ m_t^- &= 0 & \text{if} & & m_t \geq 0 \end{aligned}$$

4.10 Similarly from the prime-interbank rate cointegrating regression we construct:

$$\begin{aligned} e_t^+ &= e_t & \text{if} & & e_t > 0 \\ e_t^+ &= 0 & \text{if} & & e_t \leq 0 \end{aligned}$$

and

$$\begin{aligned} e_t^- &= e_t & \text{if} & & e_t < 0 \\ e_t^- &= 0 & \text{if} & & e_t \geq 0 \end{aligned}$$

4.11 In the case of the fixed-deposit rate, a positive m_t in period t implies that the deposit rate is above its equilibrium value relative to the interbank rate following a decline in the latter. This would require a downward adjustment in the deposit rate in the subsequent period. A negative m_t indicates that the deposit rate is below the equilibrium value with respect to the interbank rate following a given increase in the latter. This would bring about an upward adjustment in the prime rate in the following period. I_1 and I_2 represent the speed of adjustment coefficients of the deposit rate in response to the previous period disequilibrium relationship between the fixed deposit and money market rates brought about by a decrease and an increase in the interbank rate respectively. Monopolistic pricing of fixed deposit rates that aims at extracting surpluses from depositors would imply $I_1 > I_2$, i.e. banks are quicker in adjusting their deposit rate downward than they are to adjust upwards.

4.12 For the prime rate, $e_t > 0$ implies that the rate is above the equilibrium level following a fall in the interbank rate, while $e_t < 0$ indicates that the prime rate is below the equilibrium following an upward movement in the interbank rate. Monopolistic pricing behaviour in the loan market would imply $d_2 > d_1$, i.e. banks are quicker to raise their prime rates upward than they are to adjust them downward.

4.13 In order to characterise the dynamic adjustment of the deposit and prime rates to changes in money market conditions within an ECM framework, we need first to establish that a cointegrating relationship exists between these rates and the interbank rate. Table 4 presents the estimates of the pair of the cointegrating equations using the Johansen maximum likelihood procedure. The sample consists of monthly observations from January 1989 to February 1999. As indicated in Table 4, the trace statistic rejects the null hypothesis of no cointegration for each of the estimated equations, indicating the existence of an equilibrium pricing relationship between the interbank rate on one hand, and the fixed deposit and prime rates, on the other.

4.14 Using the residuals from the co-integrating equation, we estimated both the symmetric ECM models as specified in equations (18) and (19) and asymmetric ECM models as given by equations (20) and (21). The estimates are presented in Table 5. The equations are estimated by OLS with the standard errors corrected for heteroskedasticity and serial correlation using the Newey-West procedure.

Table 4
**A Co-integration Analysis of Interbank,
Fixed Deposit and Prime Interest Rates**

	i	i^D	i^P
Unit root test *	-2.122	-2.581	-2.595
<hr/>			
Cointegration Test $H_0: r = 0$	0	1	
Trace statistic for fixed-deposit-interbank rate equation	20.633	5.473	
Trace statistic for prime-Interbank rate equation	17.167	4.708	
<hr/>			
Co-integrating vector for $[i^D, i, \text{constant}]$	= [1.00	-0.721	-0.669]
Standard error for co-integrating vector	= [0.136]
Co-integrating vector for $[i^P, i, \text{constant}]$	= [1.00	-0.5105	-4.454]
Standard error for co-integrating vector	= [0.107]

* Augmented Dickey-Fuller tests of the null hypothesis of a unit root. The Mackinnon critical value for rejection of the null at 1% is -3.450. (r=number of cointegrating relations)

Table 5
ECM Equations for Fixed Deposit and Prime Rates

	Dt^D		Dt^P	
	(i)	(ii)	(iii)	(iv)
Constant	-0.006 (0.024)	-0.003 (0.026)	-0.002 (0.018)	0.020 (0.020)
Dt	0.217 (0.054)	0.217 (0.054)	0.065 (0.024)	0.064 (0.021)
Symmetric EC term	-0.141 (0.038)		-0.157 (0.037)	
Asymmetric EC term Decrease in i		-0.145 (0.074)		-0.204 (0.038)
Increase in i		-0.138 (0.057)		-0.121 (0.032)
R^2	0.436	0.435	0.441	0.449
DW	1.197	1.197	0.783	0.797
SEE	0.194	0.194	0.131	0.131

Note: Figures in parenthesis are serial correlation and heteroskedasticity consistent standard errors.

4.15 The estimates for the symmetric ECM equations indicate that the response of the fixed deposit rate to a given change in the interbank interest rate is larger than the response of the prime lending rate. In both the equations, the error-correction terms have the right sign and are statistically significant, indicating that the banking institutions adjust their prime and deposit rates when they deviate significantly from their equilibrium relationships with the interbank rate in the previous period. The set of parameter estimates allows us to calculate the mean lag of adjustment for the deposit and the prime rates following a given change in the interbank rate. The mean lag measures the average time in which a given change in the interbank rate is fully transmitted to the deposit and prime interest rates. The mean lag for the deposit rate is calculated as $(1-a_1)/I$ and it equals 5.6 months. The mean lag for the prime lending rate is calculated as $(1-b_1)/d$ and it equals 6 months. The slower adjustment lag in the prime lending rate relative to the deposit rate implies that the prime-deposit rate spread would widen temporarily following a decline in the money market rate and it would narrow temporarily as the interbank rate firms up.

4.16 We next allow for different speeds of adjustment in the prime and deposit rates for a given increase and a decrease in the interbank rate. As indicated in Table 4, the estimated asymmetric coefficients in the deposit equation are fairly close in size. A Wald test of the restriction that $I_1 = I_2$ cannot be rejected with a χ^2 value of 0.005 and a p-value of 0.946. Similarly a test for the equality of the asymmetric coefficients in the prime rate equation, i.e. $d_1 = d_2$, cannot be rejected with a χ^2 of 1.82 and a p-value of 0.177. Hence our estimates indicate that neither the fixed rate nor the prime rate displays any asymmetric adjustment pattern in response to a given upward or downward change in the interbank rate.

4.17 The absence of asymmetric monopolistic pricing behaviour in the fixed deposit and loan markets can be attributed to the highly competitive nature of the banking industry in Singapore and the openness of the economy without any exchange controls. Such a configuration of the

financial structure influences the elasticity of supply for deposits and the elasticity of demand for loans, which serves to constrain the pricing practices of the banks.

4.18 In Singapore, there are currently ten locally-incorporated banks and twenty-two foreign banks which operate under full license status, where they are authorised to conduct a whole range of banking services. These include accepting deposit accounts and providing credit facilities. However, certain restrictions exist for foreign full-banks in setting up new branches and in installing off-site ATMs or sharing ATMs with other banks. In addition to the full-banks, there are thirteen restricted banks which are permitted to engage in the same range of domestic banking activities as the full-banks except that they can only have one main branch and are prohibited from accepting local currency saving and fixed deposits of less than S\$250,000. Offshore banks are also allowed to extend local currency loans to residents up to a maximum of S\$300 million. The development of the private debt securities market as an alternative to bank loans and the use of cost of funds pegged to the money market rates for the pricing of loans serves to increase the competitiveness of the prime rate pricing.

4.19 The absence of any exchange controls has also permitted resident depositors and borrowers to freely deposit their funds and source their borrowing in different foreign currencies. These factors have considerable influence on the supply and demand elasticities of the deposit and prime rates. The five-year liberalisation programme for the commercial banking sector, by promoting greater competition and efficiency, can be expected to increase the responsiveness of retail rates set by the banks to changes in money market conditions as well as reduce the spread between the deposit and lending rates.

V SUMMARY AND CONCLUSIONS

5.1 The paper sets out to investigate the determinants of the domestic interbank interest rate and the dynamic linkages between changes in the interbank rate and the fixed deposit and prime lending rates. Our empirical analysis shows that the interbank interest rate in Singapore is primarily determined by movements in the US interest rate adjusted for the expected change in the Singapore-US Dollar exchange rate. As the model that we have estimated shows, this is a result of an endogenous portfolio balance decision in a highly open economy with a managed exchange rate regime. Before the advent of the Asian currency crisis, the differential between the US and the Singapore interest rate was largely due to expectations of changes in the Singapore-US Dollar nominal exchange rate. During the crisis, rising exchange rate risk premia and errors in forecasting future changes in the spot rate resulted in significant deviations from uncovered interest parity.

5.2 Our estimates also indicate considerable stickiness in the fixed deposit rates and prime lending rates of banks with respect to changes in the interbank interest rate. The mean adjustment lag of the prime rate is slightly longer than the mean adjustment lag of the fixed deposit. While there is considerable inertia in prime and deposit rate adjustment, there is no evidence of systematic monopolistic pricing practices that aim at extracting surpluses from depositors and borrowers.

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